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PROPOSING SOCIAL CAPITAL EXERGY OF THE HUMANITARIAN HUBS AS AN INDICATOR OF HAPPINESS

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This is an abridged version of the paper presented at the conference. The full version is being submitted elsewhere. Details on the full paper can be obtained from the author.

ISBN: 978-85-285-0232-9

13th World Conference on Transport Research

www.wctr2013rio.com

15-18 JULY 2013
Rio de Janeiro, Brazil

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ABSTRACT

Exergy is an important thermodynamic concept that can be used to study the sustainability of complex non-equilibrium social systems. This paper seeks to apply the exergy concept within the context of superstatistical framework of land use in order to develop a thermodynamically- based index for happiness.

Our work is based on earlier research work undertaken by the EASTS IRG SCAFT group on the relations between superstatistical cell Exergy units of the Humanitarian Hub (the central reference land use) and the structural factor of the common faculty. Results indicate that happiness can be measured from exergy analysis of Exergy units of the Humanitarian Hubs.

It is important to note that, while the thermodynamic concept of exergy has previously been used as an indicator to satisfy global policy objectives for sustainable development and environmental well-being, its application as a key indicator of happiness for the non-equilibrium social and urban system is a novel kind of approach.

Our findings suggest exergy can be used to develop a new objective and innovative measure for global happiness.

Keywords: Superstatistics, Exergy, Humanitarian Hub, Happiness Index

INTRODUCTION

EASTS IRG SCAFT is an international research group established by EASTS community to address the design challenge of global integration transport and urban systems using a superstatistical framework. The basic idea behind the framework is the hypothesis that complex urban and social systems are non-equilibrium gradient induced flow systems with superstatistical characteristics, in which their natural attraction toward their global attracter will cause advancing cycles of complex social interactions and hierarchical relations that are analogous with the concept of energy levels (Mojarrabi *et al*. 2009; 2011). The framework consists of multiple general superstatistical levels, with each level having their own time scale relaxation properties (Beck, 2010; and Mojarrabi *et al*. 2011).

The first is the microscopic nodal level, followed by the middle level, which consists of two sublevels: a dynamical cluster sublevel and a middle superstatistical cell sublevel. The third level is a global dynamical control level for the whole integrated system in which the density of the energy state depends (Sob'yanin, 2012).

In the microscopic nodal level, the local dynamic is characterised by the energy fitness of the individual nodes walking their path toward the global attractor, obeying thermodynamic coupled interactions (mostly, but not always, via Boltzmann trajectory localised interconnecting pathways). In this level, we consider that the state of happiness is related to how close these nodes can get to their global attracter.

The clustering sublevel occurs as a result of the anisotropic nature of the first passage time of clear time scale gradient induced flow entities (GIF entities). The anisotropy itself is a result of the positive feedback response of the individual nodes (with different fitness) at the microscopic level to their GIF central entities and will lead to the creation of gradients in the direction of the central node. As the individual node moves through the different clusters with different directional pathway toward the global attractor, it will choose those pathways that maximise his/her exergy storage and minimise his/her exergy waste (Mojarrabi *et al*. 2011).

The middle superstatistical level is determined by the dynamics of the superstatistical cell against the background of the environmental fluctuation field, characterised by an intensive parameter β. Within each of these cells, there are a number of highly-populated clusters. Humanitarian Hubs forms when a significant number of well-populated clusters, each with their gradient induced flows orient toward the centre of the cell that is a universal house of worship, suggesting religious indivisibility, with each religion being an advance in different dynamical landscapes in different time scales. These Humanitarian Hubs join together based on topological characteristics of gradient induced flows to create the global integrated urban system. Figure 1 shows the superstatistical base of land use with the centred house of worship (Mojarrabi, 2008; Mojarrabi, 2009; and Mojarrabi *et al.* 2009).

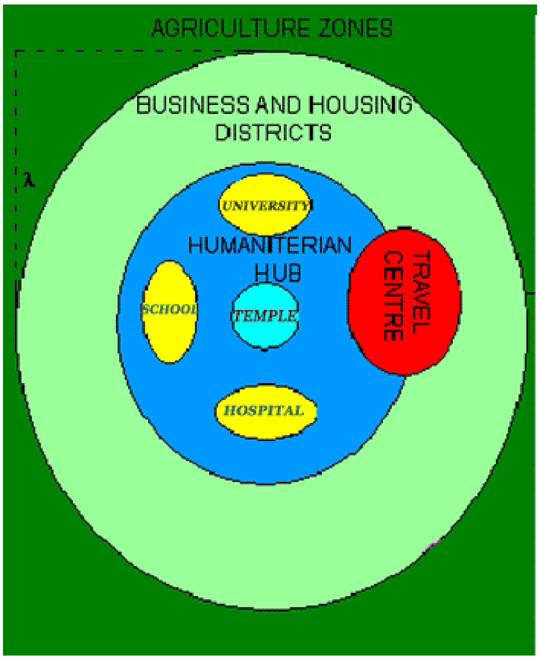

Figure 1 – Superstatistical cell with humanitarian Hub in the centre

The global dynamic of the macroscopic level is characterized by complex, internal forward and feedback control loops that act as a coordination control for global synchronisation of the Exergy units of the system. The Exergy units within the system need to be synchronized in order to safeguard the state of the health of the system that corresponds with the expanding fitness of individual nodes. This would ensure the seamless delivery of the exergy for the social capital build processes required to move the system further away from the fluctuation field in the direction determined by anisotropy of the first passage time. This direction is known in social sciences as the direction of an ever-advancing civilization sequentially marked by religious founders, the central pivot of civilization states (Institute for Studies in Global Prosperity, 2000) (see Figure 2). The Principle of Ever-Advancing Civilization of Universal House of Justice (2001) is the path these civilizations can merge into one unified global system that capable of spreading and sustaining happiness for all.

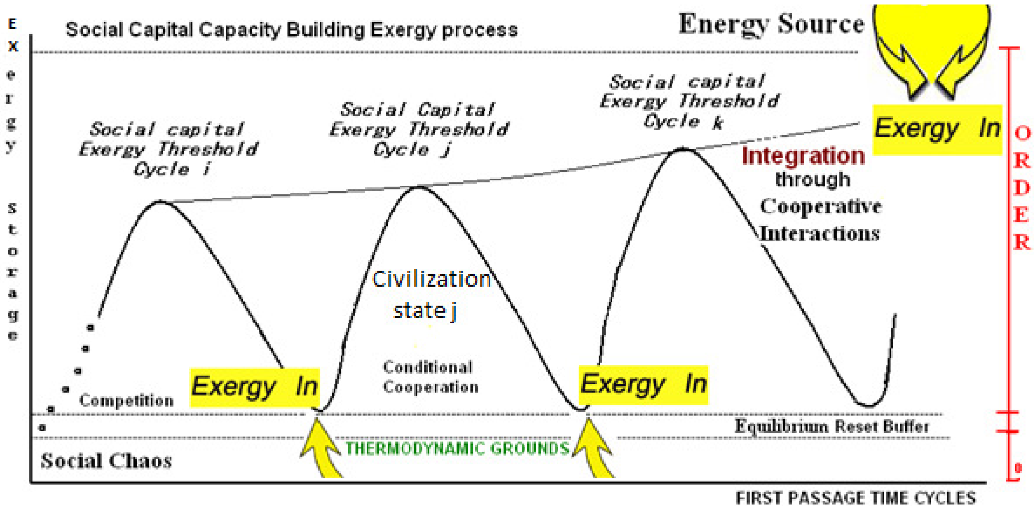

Figure 2- The Exergy based cycles of First passage time

Next, the superstatistical conceptualisation of first passage time anisotropy implies that each stage of social evolution or civilization states of an ever-advancing civilization proceeds through the information map encoded in the structural factor of the common faculty when the state is in its healthy integrated state, thus the degree of coherence between different Exergy units of superstatistical cells can be seen as a manifestations of the state of wellbeing and happiness of the social system. Now as coherence within the social system is the propagation time of cooperative interactions, then coherence length ζ is an important parameter to find out how different Exergy units of the system working together as one integrated whole.

In social construct research communities, happiness is perceived and presented as a subjective individual choice concerning life satisfaction. Naturally, such a view of happiness has a widespread appeal because it is so consistent with our personal experiences of self-organisation, the well-being, the economic prosperity and potentialities developed in advance of the common law of modernity and sustainable growth. Therefore, at first, it does seem a reasonable idea to base the index of happiness on a series of data files and individual surveys to sort out the socially constructed engineering agent technology that allow us to reconcile the individual choices with that of a socially constructed growth and developmental profile for the realization of the distinctive capacity of individual nodes. However, one of the major inconsistencies within such a view of happiness is the lack of prediction of the growth trend for what constitutes the next evolutionary stage of the healthy developmental change for the entire social system. After all, not every social change aggregated on individual preferences results into a social progress (Marshall, 2009; Boniwell, 2006; Booth 2012). Also, social constructivism does not consider that the coherence length and interaction time are factors that may cause anomalous results in survey data.

The aims of this paper are to: firstly look into the relationships between the Exergy units processes and interactions in terms of their exergy value; and secondly, to discover the main factors of happiness in a general Superstatistics model of a social system by monitoring the coherence of exergy based dynamical activities among the local clusters of the superstatistical cell reference land use.

The paper is organized as follows: we first provide a brief overview of the thermodynamic concept of exergy and its application in the field of sustainable development. Secondly, we look into the concept of social capital exergy and Humanitarian Hub exergy units;
Thirdly, we develop the thermodynamic base index for happiness; followed by a final conclusion to our paper.

We refer to synchronizability as the dynamic relationship between the nodes within the network and not to some external dynamics.

In social network links are interaction between individuals (nodes). Nodes are limit-cycle oscillators.

We can define the First-Passage Time (FPT) of transport and social network as the pumping lifetime Γ of the system. We consider the First Passage Time as the time of stable existence of the system characterized by the existence of local and global feedbacks within the system.

EXERGY AND SUSTAINABLE DEVELOPMENT

Energy is required for interaction (link coupling) between nodes. The interaction energy is characterized by its form and quality. The available quality of the interaction energy can be measured by a thermodynamic concept called exergy (Wall, 2005; Dincer and Rosen, 2007). The concept of exergy has been previously been used to determine the thermodynamic optimum of ecosystem (Eugene and Moker, 2010) and system performance structural civil engineering (Samali and Madadnia, 2001; Camberos and Moorhouse, 2009), improvement of renewable energy sources (Fiaschi and Manfrida, 2010) and sustainable development (Jorgensen *et al.* 2000; Sillow and Mokry, 2010). The exergy capital will be lost in complex non-equilibrium system due to the working defaults settings of the system. This loss need to be minimised for otherwise a step-wise weakening of the exergy flows within the system would result in the system disintegration and decay.

Concept of Social Capital Exergy

Real non-equilibrium gradient induced flow social systems obtain their required energy supplies for social interaction and activities from two different sources, one from the fluctuation field and the other from clear time scale gradient induced flow entities (religious founders) (Mojarrabi *et al*. 2011) (see figure 2).

The social interaction exergy as the measured quality of the energy that is available for social community building and structural formation works. It is called the “social capital Exergy” E_{in}^{χ} and sum of two terms:

$$E_{in}^{\chi} = E_{in}^{res} + E_{in}^{hub} \quad (1)$$

where

$E_{in}^{\mathrm{Re}\,s}$ is the exergy drawn from the thermodynamic reservoir and E_{in}^{hub} is the global exergy influx pumped by clear time scale gradient induced flow entities into the Humanitarian Hubs:

$E_{in}^{\mathrm{Re}\,s}$ is the exergy needed for competitive-based interaction and also trigger-based conditional cooperation. If the system uses only this source of energy as a social capital then

$$E_{out}^{Res} = \left(1 - \frac{T_{cell}}{T}\right) \times E_{in}^{Res} \quad (2)$$

where $\frac{T_{cel}}{T}$ is proportional to the Human Development Index (HDI) published by the United Nation. T is the global mean temperature corresponding to the entire superstatistical system. The carnet factor $\left(1 - \frac{T_{cell}}{T}\right)$ is the extent of exergy spread within the community and will lead to economic utilization of exergy. That means there is a theoretical limit to the universal participation of exergy that we can extract from a given synchronised cluster if we only consider the market-based competitive and conditional-based cooperative activities and interactions. This is because as times passes, the number of out-of-phase interactions increases until the coherence length ζ of the system reaches the phase breaking time of the carnet cycle. As a result, the coherence time become too short for the propagation length of thermodynamic necessary interactions that is needed for the individual nodes’ sense of direction and orientation toward their global attracter, thus affecting overall state of happiness within the system.

One solution is to build capacity buffers while inducing noise into the coherence. This would allow preferential changes in the exergy production, circulation and processing units as long as induced noise is far smaller than the global averages of the fluctuations of the thermodynamic grounds. The new dynamic coherence for each cycle of growth can then proceed along a statistically-preferred route as a new stage of developmental landscape. Setting up the noise threshold above or below the capacity building buffers may also prompt local GIF entities to favour the statistically-preferred route as their main synchronization route, as the cost functions for optimal control system design through this route become a more attractive alternative compared to any other route choices they can make. However, the inducing noise into the system has one undesirable side effect. The ratio $\frac{T_{cel}}{T}$ within the carnet cycle is sensitive to fluctuation noise; therefore, the processes of inducing noise into the coherence will result in the overall loss of objective consistency that can become a constrain on the number of participating nodes i.e. universal participation is not achievable with the fluctuation field as the only energy source.

The other method is to introduce an additional energy source that would enable the dynamic coherence through individual capacity building process that increases the social capital resources for collaborative and cooperative interactions.

To do this, we propose the concept of social capital exergy of the Humanitarian Hubs to develop a new more extensive and inclusive metric for happiness. The extra energy supply with the Humanitarian Hub as a central reference land use would allow a very efficient exergy storage system to substantially increase the state of coherence for the entire system without always being anxious whether the number of competitive interactions has reached to its carnet limit.

The exergy E_{in}^{hub} is the exergy required to build the social capital resources for the Humanitarian Hubs. The incident energy $L(\omega)$ would be collected by the superstatistical cell's central core house of worship within area A and transferred into the accessible form of energy. It can be calculated from:

$$E_{in}^{hub} = L(\omega)A(1-\frac{T_{hub}}{T}) \qquad (3)$$

where T_{hub} is the environmental temperature of the hub. When gradient induced flow local structures receives a flow of energy from their clear time scale GIF entity, they must work within the fitness limits of their Exergy processing units within their populated clusters in order to put the system into gear to move forward. The work will generate internal flows, causing an increase in social capital activities required for core logistical activities within the Humanitarian Hubs. This would move the system further away from the equilibrium but in a predestined direction determined by the anisotropy of the first passage time, which is now coded into the synchronisation growth process of the cluster Exergy units.

To determine the happiness index of an optimally stable global integration superstatistical system, we need to calculate the exergy that can be extracted from a given synchronized cluster within the Humanitarian Hub E_{out}^{x}.

$$E_{out}^{\chi} = N\xi_{ind}(T_{out} - T_{cluster} - T\ln(\frac{T_{out}}{T_{cluster}}) \qquad (4)$$

$T_{cluster}$ is the mean average temperature of all merged clusters within the Humanitarian Hubs

T_{out} is the mean average temperature output of cluster units of the Humanitarian Hub.

ξ_{ind} is the gradient action energy time which is dependent on the energy capacity of the individual nodes. It can be considered as social indicators of both the internal exergy level of

the storage units and how the internal Exergy processing units utilize the exergy contents in time.
N is the number of nodes attracted to a Humanitarian Hub at a given unit of time.
The exergy efficiency μ for such system is:

$$\mu = \frac{E^{\chi}_{out}}{E^{\chi}_{in}} \tag{5}$$

This is the exergy efficiency for the reversible system. In practice, for each cycle of civilization state of the first passage time, there is exergy loss and wasted as the system cannot always reach to its desirable state of coherence.

As time passes, the system develop complex exergy-based structures and integrating organisational units to increase the fitness of its individual nodes in order to minimise exergy waste and enabling them to store higher levels of exergy in order to move further away from environmental equilibrium (thermodynamic grounds), thus achieving a higher level of integration in order to advance in a direction marked by their clear time scale gradient induced flow entities.

THE EXERGY UNITS OF THE HUMANITARIAN HUB

Here, in order to simplify the complexity of the superstatistical based social system, we divide the whole system into four different Exergy-based sub-units, interacting with each other partly in the consideration of the previous research study (Mojarrabi *et al*. 2011).

The Exergy units of a superstatistical system are Exergy processing units, Exergy storage units, Exergy creative units and Exergy transfer accompanying units. A decrease in the flow rates within any one of these Exergy units would cause a change in the overall synchronisation state of the superstatistical cell. The range in which the cooperative interactions may occur depends on how the populations of different Exergy units of the system can seamlessly work together as an integrated whole. This range is called coherence length ζ and is equal to two times of the Eigenvalue λ.

$$\zeta=2\text{x}\lambda \tag{6}$$

and $\zeta=2$ for $\lambda=1$

For the superstatistical cell in figure 1, the coherence length is two times of the eigenvalue λ, in the travel time unit. The eigenvalue λ signals the case of total misdirection of the synchronized clusters in their cooperative based orientation pathways (corresponding to maximum travel time) within the humanitarian hubs (Mojarrabi *et al*, 2011). Incidentally, the coherence length 2 is also the coherence length of organic systems (Keeling *et al*. 1997).

Beyond a dynamical level of coherent length threshold $\zeta=2$, a subsequent loss of happiness occurs irrespective of the fitness of the individual nodes. This is not so surprising. The different Exergy units of the system have different exergy supply and demand needs in order to sustain the dynamic coherence required for sustaining a healthy and happy style of social life for entire population as the system walks the path from thermodynamic grounds toward the global attractor in accordance with Principle of Ever-advancing Civilization. Exergy

Processing units, Exergy storage units and creative units can use both forms of the exergy sources, while accompanying units only receive their energy from clear time scale gradient induced flow entities.

The accompanying units are those compartments that transport and transfer exergy between units while they are also work on capturing the macroscopic behaviour from the periodic and microscopic fluctuations of the individual dynamics and the cluster temperature gradients. They form a solid barrier against the temperature gradients that are aimed in the direction of the Exergy processing units by directing them toward the central Humanitarian Hub, the universal house of worship. Therefore, when they switch their exergy source to the fluctuation field, the coherent length drops significantly and abruptly even though exergy storage units of the system may still have plenty reserve of exergy.

The other reason for the abrupt loss of happiness in the system is due to creative units. Normally they create solid barriers against the rise and spread of lethargy. Creative units have unique ability to access a higher synchronisation encoded in the common faculty (even before the rest of the population have reached that stage) and so can induce transitions in the system reproductive growth behaviour. They are the units responsible for introducing and maintaining the achieved rates of system growth, the size and influence for the system. This system growth rate however is different from the spiral growth associated with accompanying units (Mojarrabi *et al*, 2011). On the other hand, one can also observe that, in cases that creative units receive their share of exergy supply only from the fluctuation filed, then they may start disorienting the exergy processing units of the system by letting lethargy into the system depleting vital humanitarian hub resources while they start growing their own populating clusters with own exergy processing units. This is possible because Exergy processing units are the last units to receive exergy and also being the units responsible for enabling and sustaining the capacity building exergy based processes that guide the individual nodes along the path leading toward the full capacity of the collective and cooperative system planning structures over finite time scales and therefore always looking for new creative ways to access exergy.

Exergy Losses within the System

1) There is a global exergy loss due to incomplete social capacity building processes and social experimentation that goes wrong:

$$E^{x}_{loss\ absorbed} = \mathrm{A}\left(1 - \frac{T_{hub}}{T}\right)(L(\omega) - S(\omega)) \quad (7)$$

Where $S(\omega)$ is the amount of energy absorbed by Exergy storage units and other Exergy units serving as Exergy supplementary storage units. The Exergy accompanying units and Exergy creative units and Exergy processing units can also serve as supplementary Exergy storage units.

2) There is a exergy loss due to the internal transport heat through work done by the Exergy units of the system that disperse into the thermodynamic ground by the accompany units.

$$E^{x}_{Acc\ loss} = \frac{N_u}{N_{AC}} A \left(1 - \frac{T_{hub}}{T_{cluster}}\right)(T_{cluster} - T_{hub}) \quad (8)$$

Where $(T_{cluster} - T_{hub})$ is the overall temperature gradient in the direction of Humanitarian Hub directed by the average number of accompanying units assigned within the superstatistical cell. Here N_u is the number of accompanying units that involve in directing and orienting the temperature gradients and N_{AC} is the number of accompanying units involved in the transport and transfer of exergy between other Exergy units. Evidently, this ratio is an important factor with regard to the system plasticity toward alternative exergy pathways.

3) There is also exergy destruction due to the remaining temperature differences between the Exergy units after the energy has been absorbed.

$$E^{x}_{exergy\ absorbed\ loss} = S(\omega)\, A \left(1 - \frac{T_{hub}}{T}\right) - S(\omega)\, A(T_{cluster} - T_{hub}) \quad (9)$$

4) Exergy waste due to gradient action exergy time of distributed work potential losses is represented by $\Delta\xi_{ind}$. It represents the amount of the absorbed energy within the Exergy processing units that could have been converted into useful work but instead failed to materialize due to a rise in the number of uncooperative interactions within and around the internal Exergy processing units which in turn will affect the ratio of $\frac{N_u}{N_{AC}}$ within the superstatistical cell. This is why Exergy processing units are the major source of exergy loss within the system.

$$E^{x}_{processing\ loss} = \Delta\xi_{ind} \quad (10)$$

The total exergy losses and destruction is then:

$$E^{x}_{total\ loss} = E^{x}_{loss\ absorbed} + E^{x}_{Acc\ loss} + E^{x}_{exergy\ absorbed\ loss} + E^{x}_{processing\ loss} \quad (11)$$

And the happiness index is:

$$\mu_{happiness} = 1 - \frac{E^{x}_{total\ loss}}{E^{x}_{in}} \quad (12)$$

This index shows the parameters affecting the state of happiness of the social system are related to the coherent dynamic achieved between the Exergy units.

CONCLUSION

In this paper we suggested the potential usefulness of exergy for evaluating the state of happiness and wellbeing of social system. In doing so, we developed a more extensive and inclusive objective measure for happiness. This index suggests that when the system is in its happy, healthy state, the coding from structural factor of the common faculty of integrated scale would result in the expected synchronisation of the entire system.
The following conclusions summarise our findings:

1) The more the system closes toward the global attracter, the more exergy it builds and the more happiness index improves.
2) Exergy processing units are the one in which the biggest loss of exergy occurs.
3) The accompanying units are the first to receive exergy, followed by creative units. Exergy Processing units are the last to receive exergy within the system.

In another conclusion, the happiness index presented here shows the interaction coherence length between the Exergy units of the system is an important parameter that we need to consider.

ACKNOWLEDGEMENT

I wish to thank Ms. Yae Oda for her generous offer of time as we discussed on many occasions the concepts presented here. I addition, I would like to thank the assistance provided by Susie Faulkner in reviewing and editing the Text. We acknowledge funding support from Sachi Foundation.

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